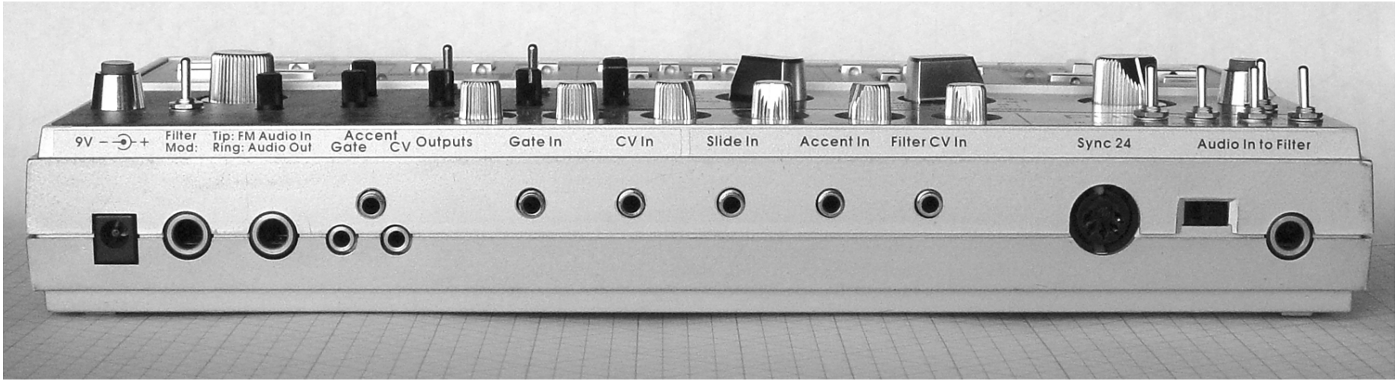
REAL WORLD INTERFACES

User Manual for the Devil Fish mods to the TB-303

Robin Whittle 6 February 2015 www.firstpr.com.au/rwi/dfish/ (Modification versions 2.0 to 4.2B.)

Contents



Introduction

This manual is for the Devil Fish modifications to the Roland TB-303's synthesiser. Please see separate manuals for the MIDI In System, the MIDI In and Out system and the 32 Bank Memory System.

This manual covers Devil Fish versions 2.0 (1996) to 4.2B (February 2015 and to the present day). It does not cover the 18 version 1.0 and 1.1 Devil Fishes from 1993 and 1994.

Starting with Version 4.2B, in February 2013, the memory backup arrangements are documented in a separate manual: DF-Memory-Backup.pdf

There are minor audible and functional differences between some versions. Four of the six V2.0 machines have a filter oscillation problem. V2.0, V2.1 and V2.1A machines create a small click at the start of the note when the Decay pot is anticlockwise and the Soft Attack pot is clockwise. V2.1B (February 1999) and later have no such clicking problems. In V2.1C and later the Filter CV input responds at approximately 1V/octave – replacing two earlier linear approaches. V2.1D (2003) introduced a new function for the Slide In input: turning on the Gate when this input is 4.0 volts or greater.

Current production Devil Fishes sound identical to all those since V2.1C, and have CV inputs which respond identically to those of V2.1D and later. The later version numbers refer to circuit board revisions, which do not alter the sound or CV behaviour.

Please note that despite our best efforts, there can occasionally be a fault which is easily fixed. For reasons unknown – but perhaps "fretting corrosion" – the contacts which form a switch inside the CV In socket sometimes fail to connect properly. The result is a wavering, out-of-tune or unchanging VCO pitch when it should be responding to the internal sequencer or to MIDI In. The solution is simple: plug something into the CV In socket and remove it – any 3.5mm plug or lead will do. This usually fixes the problem. There is no obvious corrosion or contamination problem and the sockets are otherwise entirely reliable. The "Known Reliability Problems" section has further information.

New Inputs, Outputs, Controls and Functionality

This is a list of Devil Fish features with a brief explanation. The exact voltage levels etc. are detailed in later sections.

CV Inputs

CV and Gate inputs. The CV and Gate outputs remain available too.

Two Control Voltage **inputs** to activate the **Accent** and **Slide** functions. The Slide input also activates the Gate function at a higher input voltage

Separate **CV In** to drive **Filter Frequency** in addition to the other internal signals which drive it.

CV Outputs

Accent out. + 6V signal to be used with CV and Gate outputs to drive another Devil Fish.

The TB-303's CV and Gate outputs remain.

Audio Inputs

The Mix In socket is changed to **External Audio input to the Filter**. This means the Devil Fish can be used to process external signals via the Filter, VCA and Muffler. This signal is fed directly into the filter, along with the oscillator signal which passes through the Overdrive pot.

The **tip** of what used to be the headphone jack, is now the **Audio Filter FM** input. (When using the special audio lead, this signal appears on the **White** connector.) This allows audio frequency modulation of the filter circuit. This is a sensitive input with AC (capacitive) coupling, so only the audio frequency component (say 5 Hz and above) of the input voltage affects the filter frequency. Some extremely complex and interesting sounds can result, depending on the nature and level of the audio signal driving this input.

Audio Outputs

The Headphone output does not exist on the Devil Fish – its socket is used for the Audio Filter FM input and the Filter Out signal.

The **Filter Out** signal appears on the **ring** of what used to be the headphone jack. (When using the special audio lead, this signal appears on the **Red** connector.) This is a line level output of whatever the filter is producing – the same signal which drives the VCA. This is intended to be used to drive external synthesizers, or to drive some external processor such as a reverb, distortion box etc. – the output of which might be fed back into the Audio Filter FM input or the Mix In. The level at this output is not affected by the volume control. The filter is always producing an audible signal, provided either it is self-oscillating, or the oscillator and/or external audio signal is feeding the filter and the cutoff frequency is above some harmonics of those signals. This output signal does not depend on notes being played to activate the Volume Envelope Generator which drives the VCA.

New and Changed Controls

The **Overdrive** pot controls the level of Oscillator signal fed to the filter. This varies the amount of oscillator signal between none, through normal to heavy overdrive (66.6 times normal) which causes the filter to operate under duress. There is no danger to the filter, but the sound is *big*.

The **Slide Time** pot. Normally the slide time is 60 ms (milliseconds). In the Devil Fish, the Slide Time pot varies the time from 60 to 360 ms, when running from the internal sequencer. When running from an external CV, the time is between 2 and 300 ms.

The **Soft Attack** pot varies the attack time of non-accented notes between 0.3 ms and 30 ms. In the TB-303 there was a (typical) 4 ms delay and then a 3 ms attack time.

The **Decay** pot – which used to control the Main Envelope Generator (MEG) – now controls the **Volume Envelope Generator (VEG)**. The TB-303's VEG decay was fixed at ~ 3 to 4 seconds. The first half of the pot's range varies the decay between 16 ms and 3 seconds. The second half retains the long decay but makes the final volume vary between silence and full volume – so indefinitely long notes can be produced.

On non-accented notes, the TB-303's **Main Envelope Generator (MEG)** had a decay time between 200 ms and 2 seconds – as controlled by the Decay pot. On accented notes, the decay time was fixed to 200 ms. In the Devil Fish, there are two new pots for MEG decay – **Normal Decay** and **Accent Decay**. Both have a range between 30 ms and 3 seconds. The MEG drives the filter via the Env Mod pot. On accented notes the MEG also drives the filter frequency via the Accent pot which drives the Accent Sweep Circuit. The output of the Accent Sweep Circuit adds to the VCA volume, in addition to the current produced by the Main Envelope Generator. The Accent Sweep circuit, together with the Resonance Pot turned to the right, gives the distinctive acidee "wow" upwards filter sweep at the start of accented notes. Now that the time of the MEG can be manually controlled for accented notes, the "wow" or "wapp" time can be made shorter or longer.

In addition, this sweep circuit can be disabled with the **Accent Sweep Switch**. Disabling it stops the filter and VCA being affected by the MEG's output via the Accent pot. However, accents will still be audible due to the different time of the Env Mod filter sweep if the Accent Decay time is different from the Normal Decay time and the Env Mod pot is turned up.

There is a pushbutton switch to **activate Accent manually** at any time.

In the standard TB-303, the Resonance pot drives a special circuit – the **Accent Sweep Circuit** – to pulse the filter frequency and add to the volume on accented notes. When the Resonance pot is anti-clockwise, this is basically a direct pulse proportional to the setting of Accent pot, and is derived from the MEG. When the Resonance pot is clockwise, this pulse goes through a "lag" circuit which causes the filter to sweep up at the start of the note. This gives the distinctive TB-303 resonant "wapp" sound. In the version 2.0 and later Devil Fish, three modes are available, selected by the **Sweep Speed** switch. (Several of the 1.x Devil Fishes were retrofitted with this switch.)

The Sweep Speed only operates on accented notes, depending on the setting of the Accent pot and the time of the MEG as controlled by the Accent Decay pot. The differences between the modes are most pronounced with a series of accents on short consecutive notes. (Turn the filter into self resonance and turn down the Env Mod pot to hear the differences.)

- **Sweep Speed Fast** mode: The first accent causes a strong positive output, but subsequent accents produce a smaller output.

- **Sweep Speed Normal** mode: This is the same as the standard TB-303. The first accent causes a positive output, but when the resonance pot is fully clockwise, this sweeps upwards and some charge remains in a capacitor (C13) by the time the next accent occurs. Consequently the second and subsequent accent pulses cause a higher output than the first. *This is one of the keys to the emotional nature of the TB-303 – you poke it and it squeals a little . . . you poke it again and it squeals even more.* The machine gets worked up at these repeated proddings – and the charge is stored in C13. Humans interpret such responses as “I can’t stand it!!” – the response of an organism under stress and/or provocation.

- **Sweep Speed Slow** mode: Similar to normal mode, but with a much longer time-constant. The output takes longer to rise, but it can rise twice as high. It also takes longer to cool down. This can be perceived when the filter frequency is settling down in the half second or so of non-accented notes which follow.

The Accent Sweep circuit, described above, is disabled when the **Acc Sweep – Hi Resonance** switch is in its lower position. With the switch in the mid and upper positions, the circuit is in operation.

The range of the Resonance control can be switched to double the usual feedback so as to **allow the filter to self-oscillate** at mid and high frequencies. Since the Overdrive pot enables the VCO signal to the filter to be turned down to zero, the filter can be oscillating by itself and the VCO signal can be introduced manually by turning up the Overdrive pot. The high resonance is selected by the mid and lower positions of the **Acc Sweep – Hi Resonance** switch.

In the TB-303 the filter frequency was not affected by the pitch of the note the oscillator was playing. The **Filter Tracking** pot enables the filter frequency to track the note being played. The range is from 0, through normal tracking to over-tracking. This is imprecise, so it is not possible to play accurately tuned notes using just the self oscillating filter. The centre note for zero change in filter frequency is approximately C (2 volts) or D (2 2/12 volts) at the bottom of the normal octave – an octave above the lowest C in the “Transpose down” octave. Notes below this will cause the filter frequency to go down when the Filter Tracking pot is turned up. The circuit is not very accurate – the exact note which is the “zero point” depends on what else is driving the filter frequency: the Cut Off pot, the MEG signals coming through the Env Mod pot, the Accented MEG signal coming through the Accent Sweep circuit and the external filter input voltage. The higher the filter frequency as a result of these inputs, the higher the “zero point” note for the Filter Tracking pot. At maximum, the maximum Filter Tracking is about 2.7 kHz per volt (i.e. the filter goes up ~2.7 kHz when the oscillator CV goes up an octave. At higher filter frequencies, this is not as significant as at low frequencies.

One important use of Filter Tracking is for some low notes to cause the filter frequency to go below the first harmonic of the oscillator signal – or at least to go below the lowest harmonic of whatever signal is passing through the filter (since both the Oscillator and Audio In to Filter signals drive the filter). This cuts the sound off entirely, or almost entirely, for these notes.

The **Filter FM** pot frequency-modulates the filter frequency with *the audio output of the VCA*. So the output signal of the filter passes through the VCA (which includes the Muffler on its output) to the Filter FM pot, which feeds none, some or a lot of this signal back into the filter frequency. This gives edginess and complexity dependent on the signal level coming out of the VCA – so it is stronger on accented notes. At higher settings, the results approach chaos.

A three position **Muffler Switch** is provided. This affects the output of the VCA and provides two types of muted clipping. This distortion is unique to the Devil Fish and is only roughly comparable to fuzz clipping. It softens the loudest extremes of the sound and introduces a moderate level square wave clipping buzz, whilst allowing the bass to pass largely unaffected. The Muffler affects sounds which are louder than usual – those resulting from high levels of Accent or Overdrive or high level external audio input signals. It has little or no effect when the signal level at the VCA output is low.

New Functionality

Bass response is improved. In the TB-303, 32 Hz was down by 5 dB. Now it is down by 1 dB.

In the TB-303, the start of the audible note was between 1 and 5 ms (typically 4 ms) after the start of the gate signal. In the Devil Fish, **notes start within 0.5 ms**.

In the TB-303, the decay at the end of an unaccented note was about 16 ms – 8 ms of normal volume and 8 ms of linear decay. In the Devil Fish, this is now a more natural logarithmic decay which starts immediately after the gate signal ends.

The range of the filter's **Cut Off Frequency** pot has been increased so it goes higher and lower. The maximum resonant frequency of the filter, with no Env Mod or Filter Tracking, is approximately 5 kHz. This is an octave above the typical maximum for the TB-303.

The **Env Mod** pot range has been tripled and made to include no Envelope Modulation.

There is an on/off LED to show when the Gate is active. This LED is located in the 'e' of the Devil Fish logo.

Two LEDs show, by their brightness, the output voltage of the Main Envelope Generator (MEG). One is for the normal notes and the other is for accented notes. These are located adjacent to the Normal Decay and Accent Decay pots which control the MEG.

The maximum cut off and resonant frequency of the filter is limited to approximately 20 kHz. This is to reduce the likelihood of oscillations at extreme frequencies which may cause undesirable outcomes with digital audio ADCs, loudspeaker systems and canines.

Within the limitations noted above, regarding bass response and starting and ending of notes (which are generally not perceptible), the Devil Fish can still sound exactly like the TB-303. Details of restricting it to the TB-303 subset of its sound potential are in the next section.

The battery arrangements for retaining memory contents in Devil Fishes are discussed in detail in a separate manual: DF-Memory-Backup.pdf. (Devil Fishes with the Quicksilver 303 system need no batteries for their non-volatile pattern, track and configuration memories.) The following is a summary of the options.

Until early 2015, we installed a soldered-in cylindrical lithium battery in order to keep the memory alive for at least ten years. Since then, due to restrictions on lithium batteries in air-freight, with Version 4.2B and later, we use one of two arrangements – Options B and C – both of which involve a larger capacitor to retain the memory data for longer, in the absence of C-cell batteries and external power, and an under-voltage shutdown arrangement to ensure the C-cell batteries cannot be completely discharged if the machine is accidentally left running from them for an excessive time.

Option B involves an internal holder for a 2032 coin cell (20mm x 3.2mm thick "button cell) lithium battery, *without any battery installed or supplied*. We can ship the machine overseas like this, without C-cell batteries and the capacitor will generally retain memory data during the four days to two weeks it takes to be delivered to you, the customer. You can then install a 2032 battery in this holder, if you want to open the machine, or get a technician to do so. The lithium battery is not required, since you can safely retain data by installing alkaline C-cell batteries in the main battery compartment. The optional lithium battery, if installed, ensures data retention for 10 years or more even if no C-cells are installed.

Option C is only for machines we ship to Australian customers. It is the same as just described for option B, but we install a 2032 battery in the internal holder.

Limiting the Devil Fish to TB-303 sounds

The Devil Fish's "sound-space" is immense. A mild-mannered subset of this space is that of a standard TB-303. Some users wish to restrict themselves to that space for sacred occasions. Here are the limitations to observe. The original pot settings are specified in terms of a clock face. For instance the third line from the far left position is 9 o'clock

Filter Cut Off	Between about 10.30 and 3 o'clock.
Resonance	No limits.
Env Mod	Between 12 and 4 o'clock. (The lower limit of envelope modulation was not zero in the TB-303, but it is in the Devil Fish. The upper limit in the Devil Fish is about 3 times what it was in the TB-303.)
Decay	Fix at 12 o'clock. This pot now controls the Volume Envelope Generator, which had a fixed decay time in the TB-303.
Accent	No limits.
Overdrive	Fix at 2.
Normal Decay	No lower than 2. This pot performs the function which the Decay pot on the TB-303 did.
Accent Decay	Fix at about 2.7.
Filter Tracking	Fix at 0.
Soft Attack	Fix at 2.
Muffler	Fix at 0.
Slide Time when using internal sequencer	Fix at 0.
Slide Time with External CV	Fix at 5.
Sweep Speed	Fix at Norm.
Accent Sweep	Fix at 2.
Filter FM	Fix at 0.
Bass EQ	The TB-303 has a weaker bass response than the Devil Fish. To replicate this, roll off the 30 to 60 Hz band by a few dB.

What Does it Sound Like?

Sound samples are available at the web site's sounds/ directory.

The musical implications of all the above changes are diverse and extreme. If you are interested in solid, heavy bass sounds, idiosyncratic synthesis or weird-and-wonderful sounds you have never heard before, then I promise you that you will really enjoy the Devil Fish. The expressiveness and pushiness of the Accent system – especially with the Filter FM which is boosted by the higher VCA output on accented notes – gives a unique range of dynamics. The Devil Fish can produce extreme output levels. Caution and/or a limiter should be used during live performance.

The TB-303 has five pots (not counting the tuning pot and the square/sawtooth switch) which define its sound – so there is a five dimensional space of sonic possibilities. In the Devil Fish, the range of four of these is expanded, and in addition, six new pots (not counting the Slide Time pot) and three new switches are added, so the sonic possibilities inhabit a 14 dimensional space, not counting the external inputs for audio into the filter and audio Filter FM.

I have discovered all sorts of exciting musical possibilities within this space – which is of course entirely dependent on the notes and accents the machine is playing. You will discover some of these and many that I have not yet found. If you have an exploratory nature, the Devil Fish will enable you to prowl powerful, exquisite, grungy and bizarre musical hunting grounds. All normal TB-303 operations are still possible, including "acid" type filter sweeps. Only minute details such as the delay in the start of the note and the lag at the end are not possible with the Devil Fish, but these delays would generally be regarded as problems rather than a part of the TB-303 sound.

You don't really need documentation to get great sounds from the Devil Fish. Just treat it like a child's activity set – play with the knobs and switches and you will find some good settings. I recommend that you write them down because it is impossible to remember the positions of 13 knobs and three switches. I recommend you roll tape (or hard disc or FLASH memory . . .) and make music directly as you explore it. Don't try to make yourself an expert before you start recording.

Safety and Reliability

Devil Fish sounds may be seductive and powerful. Minor safety problems include the phenomenon of small household items being vibrated so as to fall from shelves. More serious a problem is the level of sound you can subject your ears to without realising it. Late at night, my ears become fatigued and I get low frequency tinnitus – I hear tones constantly droning. Please use this machine with caution!

Live sound with the Devil Fish could be problematic, since some sounds are extremely loud and contain large bass transients. I try not to leave mine sequencing away to itself audibly for no good purpose – it does something unpleasant to my brain. The long-term effects of Devil Fish exposure have not been properly researched, so caution is indicated. The person who first took possession of a Devil Fish (actually, its the other way round . . . one places oneself in the care of the Devil Fish) in 1993, emailed me in 1997 – four years after writing something like "*We were jumping up and down, literally bouncing off the walls, shouting This is what we want! This is what we want!*" The time had come, he wrote, to pass the Devil Fish to someone else. He was talking about settling down,

leading a healthy life . . . following simple pursuits . . . Four years engagement with the Devil Fish and this spirited artist was signing his emails . . . “mooooooo”.

Please try to avoid spilling things into the Devil Fish. The basic machine, and especially the modified machine, is difficult to work on. Never spray anything inside the Devil Fish, or any other item of electronic equipment, ever. Pure water does the machine little or no harm, so don’t worry if it gets rained on. Any other liquid is a cause for concern – so take it to a technician to have them investigate. Sticky things like rum and coke can be washed away with water, but only by someone working very carefully inside the machine.

The pots and switches are made by Alps (Japan) and C& K (USA) and are of the highest quality. However they could be damaged by excessive force. Always pack the Devil Fish in soft cloth inside a sturdy case. Never leave it floating around with other gear. Try to keep dust out of the machine. Dust will ultimately make the pushbutton switches bounce. Avoid packing it directly in plastic/rubber foam. Sometimes fragments of foam can become wedged between the Accent pushbutton and its surround.

Only use a 9V DC adaptor – not a 12 volt or an AC adaptor. Some, probably most, “9V” adaptors actually put out higher voltages depending on the load current. A properly regulated supply is best, but the machine generally seems to tolerate moderate over-voltages gracefully. (However, see the notes below under the Q45 part of the Reliability section.) Don’t leave batteries in the machine, unless you are about to use it without a power supply. There is serious danger of the machine being left on, or the volume/power knob being turned when in transit. This would flatten the C cell batteries and may cause leakage of corrosive liquids. Corrosion from battery leakage is a very common problem with TB- 303s and the damage can be hard to fix.

When you are turning the pots (of the original TB-303 or Devil Fish) do not press down excessively. With the original pots at least, this can wear out the conductive tracks and destroy the pot. Please note that the standard TB-303 pots can fail – they are all getting on for 30 years old. In particular the Resonance pot, which is a dual pot, can fail without warning. The problem is often where the lugs are crimped to the conductive tracks – and no repair is possible (though some success has been reported with silver-loaded conductive epoxy). These pots have not been manufactured since the early 1980s and no more are available from Roland. Se the web site’s 303-mods.html page for details of replacement pots for the TB-303.

As noted in the Reliability section, the three-position toggle-switches used in the Devil Fish can be worn out by lots of usage. They remain functional, but lose their clear three-position tactile feel. Don’t flick these switches unnecessarily or with excessive force.

All Devil Fish’s controls, inputs and outputs are fully tested before I return them to the owner. I cannot be responsible for failed TB-303 pots or other faults in the basic machine during or after shipment. The modifications are guaranteed for 2 years. Since the exact cause of the fault may not be apparent until after the machine has been repaired, faulty machines must be shipped at the owner’s expense to me and I will refund freight costs in the event of a warranty repair – or charge for labour, parts and return freight if the problem is not covered by the warranty. Before sending a machine, be sure to email or phone me with a precise description of the problem. There may be no real problem at all – or perhaps it would be better to take it to a local technician who I will help via phone or email.

Please also see the section below on *Known reliability problems*.

Audio Input Voltages

The two audio inputs – Filter FM (Tip of what used to be the Headphone jack) and Audio In to Filter (Mix In jack) require line level signals. Microphone or guitar signals are not high enough. -10 dBm line level signals will be OK, but you may want to drive something harder so you will need a higher level. You can't do any damage by driving large audio signals into these inputs.

Gate, Slide and Accent Inputs

The three new inputs – Gate, Slide and Accent are all high impedance inputs expecting a positive input voltage. Impedance is at least 10k ohms and no damage will result from putting + or - 15 volt signals into these inputs. They are all "On or Off" inputs – where a positive voltage above about 2 to 4 volts is seen as "On". The typical thresholds are:

Gate In	3.5 V. (1.5 V for versions 2.1C and earlier.)
Accent In	2.3 V.
Slide In	2.3 and 4.0 volts for the two aspects of its operation. (This is for V2.1D and later – see the more detailed information below in the Slide section).

A typical application is the Accent In voltage being driven by the velocity output of a MIDI to CV converter, so that those notes with a velocity above some particular value get played with Accent on. Similarly, the Slide In could be driven from another output voltage from the MIDI to CV converter – such as a mod wheel output voltage.

Filter CV Input

This enables an external control voltage to affect the filter frequency, in addition the internal processes which are driving the filter frequency, and in addition to the audio frequency modulation input on the tip of what used to be the headphone socket. That audio frequency input is capacitively (AC) coupled. It only passes rapid changes in voltage, so it does not enable normal CV control of the filter frequency.

The Filter CV Input socket is directly (DC) coupled, so all components of the input voltage will affect the filter frequency. An audio signal into this input can cause audio FM of the filter, but the primary purpose of this input is to enable an external voltage, such as that produced by a MIDI to CV converter from MIDI Mod Wheel messages, to control the filter frequency.

Beginning with version 2.1C, the Filter CV input is approximately 1 volt per octave. (Previous versions were linear and are described below.)

The "resting" voltage of this input is approximately 3.3 volts and its input impedance is about 105k ohms. When no signal is applied to it, its voltage is 3.3 volts.

If a higher voltage than this is applied, the filter frequency will rise. For instance, if 4.3 volts is applied, this will raise the filter frequency approximately an octave above what it would otherwise be, as a result of the internal factors which affect the filter frequency

(Cut Off, Env Mod, Filter Tracking, Accent and Filter FM) plus the AC-coupled audio modulation from the tip of the old headphone socket.

The filter is not a precise system and this input has a nominal 1 volt per octave response. This response is not tested or guaranteed. It may change with temperature, and with the many other things which are driving the filter frequency.

A good way of driving the Filter CV In would be a 0 to 5 volt Mod Wheel output from a MIDI to CV converter. That will give approximately a 5 octave frequency range, which is pretty drastic. If your MIDI to CV converter only has a 0 to 10 Volt or 0 to 12 volt output, or if you find the input too sensitive with 0 to 5 volt, then drive this input via an external 100k resistor, or something higher. You can use a 500k pot in series to provide a good range of sensitivities. If you don't know how to solder a lead with a resistor in series, then ask a technician to make one for you.

Due to the nature of the TB-303 / Devil Fish circuitry, large step-like changes to the filter frequency (those from the external CV input or the Filter Tracking pot) do not cause a perfect change to the filter frequency. Perhaps 99.8% of the change occurs instantaneously (less then 1 millisecond), but there is a residual drift towards the final frequency over the next 500 msec or so. This is caused by a number of capacitors in the machine, which are resistively coupled to a summing point for filter frequency which changes its voltage slightly. This is only noticeable with the filter self-resonating, and with relatively large changes in filter frequency.

The final frequency of the filter depends on a number of internal and external factors.

- The Cutoff Pot.
- The Main Envelope Generator via the Env Mod Pot.
- On accented notes, the Main Envelope Generator via the Accent Sweep Circuit (three modes controlled by the Sweep Speed switch), if the Sweep-Resonance switch is in positions 1 or 2.
- The AC coupled output of the VCA (which incorporates the Muffler) via the Filter FM Pot.
- The CV (from the internal sequencer or from the external CV input) via the Filter Tracking Pot. (Linear.)
- AC coupled signal from the Audio Filter FM input (tip of old headphone socket). (Linear as well.)
- DC coupled signal from the Filter CV Input. (Exponential: ~ 1 volt / octave.)

The Tuning pot does not affect the filter frequency. It only affects the Voltage Controlled Oscillator.

Filter CV In for Devil Fishes prior to 2.1C

With versions 2.1A and earlier, this input had an unloaded voltage of about 1.0 volts. Applying a voltage below this would lower the filter frequency. With version 2.1B, the unloaded voltage was about 3.7 volts. Any voltage below this will lower the filter frequency and any voltage above this will raise it. The 2.1B arrangement is a lot more sensitive then 2.1A – a given range of input voltages will achieve a wider variation of filter frequency. For voltages below about 4.2 volts, the sensitivity is about twice as sensitive. Above 4.2 volts it is about ten times as sensitive. This enables finer control of lower frequencies, whilst still allowing for very high filter frequencies. Like the other CV inputs, any input voltage in the +/- 15 volt range is safe. Probably a 0 to 10 volt range is ideal for driving the Filter CV Input.

Version 2.x Devil Fishes prior to 2.1C had linear responses to the external CV (albeit with two slopes in 2.1B). This the system more musically sensitive at lower filter frequencies compared to higher ones. Version 2.1C and later has an exponential – approximately 1 volt per octave – response. This means that whatever frequency the filter is with in input of, say, 3 volts, it will be at twice that frequency with 4 volts, and four times that frequency with 5 volts etc.

Filter Tracking pot

The voltage to frequency function of internal Filter Tracking pot is linear. While the pot is a log pot, which I have made a little more linear, the relationship between the internal CV (from the internal sequencer or external CV In) and the filter frequency is linear in a volts to Hertz sense. So, for instance, with a particular setting of the Filter Tracking pot, and the CV (from an external source, or the internal DAC, as driven by the internal sequencer or MIDI In system) equal to say 2 volts, and with all the other settings (Cutoff pot etc.) the filter might have a cutoff / self-resonant frequency of say 1 kHz. With a CV of 3 volts this would become 1.5 kHz, with 4 volts it would become 2 kHz and with 5 volts, it would become 2.5 kHz. The result of the linear system is that high notes (CVs of 3 to 5 volts) lead to only moderate increased in filter pitch (when considered in octaves or semitones), while low notes (1 to 2 volts) lead to dramatic drops in pitch (again when considered by an exponential scale such as octaves or semitones).

I tried an exponential (logarithmic) approach (1 volt/octave and beyond, to 0.33 volt/octave – as is typically found on other synthesisers) and decided the linear approach was much more interesting.

Synthesizer Accent and Accent Out

The Accent function of the internal synthesizer and the Accent Out signal are both activated when any of the following are true:

1 The internal sequencer is running and an accented note is being played.

2 The internal sequencer is not running, but the last note had the accent on.

3 The Accent In socket has more than about 2.3 volts going into it.

4 The red "Accent Pushbutton" on the right of the front panel is pushed.

Point 2 is worth remembering, since you may be driving the Devil Fish from an external CV, Gate and perhaps from and external Accent voltage, but you may not hear every note being accented in the sound coming from the machine. It may not sound this way, but the constant activity of the Accent MEG LED, and the lack of activity of the Normal MEG LED should alert you to the problem. The likely cause is that you were playing the machine from its internal sequencer and stopped it on an accented note. The solution is to start it again and stop on an unaccented note, or to turn the machine off and on again.

According to one report, depending on the contents of the memory and the settings of the Track/Pattern and the Mode switches it is possible that when you turn the machine on, the internal sequencer will be in this accented state. I have not observed this, but it can probably be fixed by clearing pattern 1A, or the first pattern of the song in whatever group you have selected when you turn the machine on.

Synthesizer Gate and Gate Out

The Gate Out follows the Synthesizer Gate which is on when one or more of the following are true:

1 The internal sequencer is playing a note. This will happen when the sequencer is running or when you are playing notes in the programming mode.

2 The Gate In socket has more than about 3.5 volts (1.5 volts for version 2.1C and earlier) coming into it.

3 The Slide In voltage is above its second threshold. (Version 2.1D and later only.)

If you are playing the Devil Fish from external CV and Gate, and you have the internal sequencer running as well, then both these will be driving the synthesizer gate, so you may get weird sounding notes. You can use this to advantage if you want some out-of-sync notes playing in addition to the normal ones. You can also have the machine running from external CV and Gate, but add in your own notes (Gates) by putting the machine into Pattern Write, Pitch Mode, and pressing any of the 13 note buttons.

The Devil Fish uses the standard TB-303 Gate Out circuit. This is driven by a diode and a 1K resistor inside the machine. It goes high to 12 volts when the Gate is on. If you short it to ground (for instance as you plug a lead carrying this signal into a socket), the extra

current could upset the Devil Fish / TB-303, but will not cause damage. This is a high gate voltage. If you need to drive a Moog or Korg active low gate, you will need a little circuit comprising of two resistors and a transistor to invert the polarity of the signal. (In my experience, Mini-Moogs are entirely unsuitable for driving from external CV and Gate, unless they are extensively modified.)

CV Out

The standard TB-303 CV Out is connected directly to the output of an op-amp – this ensures an accurate voltage even when it is driving a lower impedance device. The output can handle being shorted to ground but the Devil Fish / TB-303 machine will not like it. You should ensure that it never gets connected to a signal which tries to drive it below ground or to any other voltage – since this could damage the op-amp. The CV Out carries the voltage of the internal DAC, after it has passed through the slide circuit. If an external CV is driving the machine through CV In, then the internal DAC is ignored and the input CV is passed through the slide circuit to drive the internal synthesizer and the CV Out.

The Tuning knob only affects the tuning of the oscillator of the internal synthesizer. The Tuning knob has no effect on CV Out, Filter Frequency or Filter Tracking.

The range of the CV Out is 1 to 5 volts when driven by the internal sequencer. It may range a little above or below this when an external CV is used. The internal sequencer produces a voltage in the range of 1 to 5 volts. This represents the 3 octave range of a pattern which can be transposed by up to an octave. 2 Volts is the normal C at the left of the keyboard, 1 volt is the C an octave below. 3 Volts is the C at the right of the "keyboard" and 4 volts is that C transposed up an octave. In pattern play mode, you can press "Pitch" and one of the 12 keys to transpose the pattern up by 0 to 12 semitones, so the normal 1 to 4 volt range can be transposed to as high as 2 to 5 volts.

When the internal DAC is driven by the MIDI In system, it can go 3 semitones below and above this range: 0.75 volts to 5.25 volts. These extra semitones at the top of the range may not be entirely in tune, since the Devil Fish has a clipping circuit to limit excessive CV inputs and that circuit begins to be activated above about 5.0 volts.

CV In

The CV may be usable somewhat below 1 volt. Do not put voltages below 0 or above +5.25 volts into the CV input. The Devil Fish has a protection circuit to guard against these voltages, but it is best that you avoid them nonetheless. Many MIDI to CV converters are capable of going below 0 volts or above 5 volts.

Slide Slew Times

The Slide Time pot gives you longer slide times than normal and can give you shorter times when running from CV In.

The slide time – how long it takes for the internal CV to the Oscillator (and Filter Tracking Pot and CV Out) to slew from one level (and therefore oscillator pitch) to another – is proportional to the sum of three separate resistances. Resistance is an electrical term similar to impedance. A firehose has a low resistance to water flow while a drinking straw has a high resistance. The slew time is theoretically infinite. The times mentioned above, in the New and Changed Controls section, of 360 milliseconds etc. refer to the approximate audible time it takes to reach the final frequency. But in any resistor capacitor arrangement, the final voltage is never precisely reached – it is only approached closer and closer as time progresses.

When the Slide is activated, the internal DAC or the CV In drives a capacitor – which is like a large tank. If the source of Control Voltage (Voltage is like the pressure or level of water) has a high resistance, then it will take longer to bring the capacitor (tank) to the final level, so the slide time will be longer. The three resistances in the slide circuit are:

1 The resistance of the DAC (Digital to Analogue Converter) in the TB-303's internal sequencer. This is 100K Ohms (100,000 Ohms). Alternatively, if you are using an external source of CV, the resistance of the source of CV which is likely to be very low – 100 Ohms or less (equivalent to a firehose).

2 A 3.3K Ohm (3,300 Ohm) resistor in the Devil Fish CV voltage protection circuit. When thinking about slide, this is a very low value – close enough to zero.

3 The resistance of the Slide pot: between 0 Ohms (anti-clockwise) and 500K Ohms (500,000 Ohms = very high resistance equivalent to a long, narrow drinking straw) when turned fully clockwise.

The usual rather fast slide of a TB-303 is caused by the 100K resistance of the DAC feeding a 0.22uF capacitor. If you are using the internal sequencer and have the Slide pot turned fully anti-clockwise, you will get almost the same slide speed, due to the 100K DAC resistance and the 3.3K protection circuit voltage giving a total of 103.3K Ohms. By turning the Slide pot you can add to this resistance to give a slower slide time – up to a total of 603.3K Ohms, or a time 6 times longer than normal.

If you are running from an external CV, and the Slide pot is fully anti-clockwise, then the resistance will only be 3.3K Ohms (assuming that the source of CV has a very low resistance). This low value will give you a very short slide time: so short that you will not hear it. If you turn the Slide pot a little towards the clockwise position, you will be able to find a position which gives you the usual slide time, where the Slide pot is at about 100K Ohms. By turning it fully clockwise, you will get a total of 503.3K Ohms – about 5 times the usual slide time.

If you want extremely long slide times, feed the CV into the Devil Fish through a resistor, where the value is 470K Ohms or above. Values above several Meg Ohms may result in a loss of pitch accuracy. There is a trimpot inside the Devil Fish to adjust for the bias current of the slide buffer op-amp, to minimise the mistuning which would otherwise

occur with high impedance inputs, but this may not be entirely accurate over all temperatures, or at the highest and lowest pitches

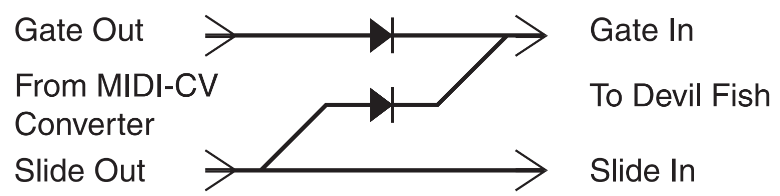
Slide In Thresholds and Gate

In versions 2.1C and earlier, the Slide In had a single function: to turn on the slide slew circuit. Slide In did not turn on the Gate of the synthesiser. This meant that if the internal sequencer or external source of Gate (such as a MIDI to CV converter) was producing two separate periods of Gate On (that is two discrete notes in time) at different pitches (different CV voltages) then this input could not "tie" the two notes together, as is commonly desired for the musical concept of "Slide".

In versions 2.1D and later, the above functionality can still be achieved, by driving Slide In to about +3 volts. The first threshold voltage is about +2.3 volts – to turn on the slide slew circuit. There is a second voltage threshold, present only in versions 2.1D and later, at about +4.0 volts. This turns on the synthesiser's Gate and the Gate Out signal as well. Thus, when Slide In is driven above +4 volts, not only is the slide slew circuit enabled, but Gate is turned on, which has the musical effect of making the Gate In signal irrelevant: it "ties" any and all "notes" into one long note event, as long as the Slide In is above 4.0 volts.

For most musical purposes, simply drive Slide In with 5 volts or more – anything up to 15 or 30 volts will do. Use about 3.0 volts if you want to turn on the slide-slew circuit whilst leaving the synthesiser notes to be driven independently by Gate In or the internal sequencer.

Devil Fishes prior to version 2.1D can't internally use the Slide In voltage to turn on the internal Gate. However, a simple arrangement of wiring outside the machine will perform the same function. A technician can create a set of cables, or a small adaptor box, with diodes so that either the Slide or the Gate voltage from the MIDI to CV converter drives the Devil Fish's Gate In:



See also the discussion below in the Version History.

Accent Sweep Switch and Resonance

Here is a tabular description of the two functions of this three-position toggle switch.

Accent Sweep Switch	**Accent Sweep circuit enabled**	**Resonance High** means the filter will self resonate at mid & high frequencies when the Resonance pot is past about 2 o'clock.	Use it for:
2	Yes	Normal	Acidee sounds with the Resonance pot fully clockwise.
1	Yes	High	Whistly filter sweep sounds.
0	No	High	Self resonant filter with no sweep on accented notes.

Overdrive, Filter Resonance and Audio Filter FM

Audio Filter FM has the most effect when the filter is most resonant. Audio signals for Filter FM come from the Filter FM pot and from the tip of what used to be the Headphone jack. The resonance of the filter is quenched when the filter is driven by a heavy input signal – the filter hits its limits at the high and low extremes of the waveform and cannot resonate at these limits. The filter can be driven hard with the Overdrive pot and/or an external signal plugged into the Mix In socket.

On the other hand, since the internal Filter FM pot is driven by the output of the VCA, and this VCA output signal is likely to be much higher with the Overdrive pot turned clockwise, extreme internal Filter FM will occur, at the same time as the filter is being overdriven by the 66.6 times normal level of oscillator signal. Seriously loud and complex sounds!

Furthermore, if you carefully use a mono or stereo plug in what used to be the headphone socket you can achieve even higher levels of Filter FM. Whether or not the tip of the plug connects to anything (such as a mixer or reverb input) and assuming it is not driven by some external signal, then you can use the tip of this plug to connect the "ring" of this socket (Audio Out from the Filter, before the VCA/Muffler) straight to the "tip" of the socket: Filter FM In. There is a position just a few millimetres short of full insertion which connects the two parts of the socket together. This is different from the Filter FM pot system in several ways. Firstly, there is no control over the level of this type of Filter FM. (Use a proper stereo plug and lead, with external pot, mixer, gain control, etc. if you want to control it.) Secondly, the level is potentially more intense than with the Filter FM pot. Thirdly, this is continual FM, not dependent on "notes" via the VCA being turned on. Finally, the polarity relationship between Filter audio output voltage and its control voltage is the opposite of that of the Filter FM pot, so depending on the gain of the VCA, the two may cancel to some extent, or more likely greatly complexify the final audible result.

Rather than try to analyse and understand, its better to simply try this!

Turning up the Overdrive towards maximum, and then with Filter FM turned up high, it is possible to have sounds which, depending on other things, descend into a spluttering

chaotic mess. At times, I have had this arrangement with the controls finely tweaked so that on some cycles through a pattern, the filter resonates with the spiky, “nutty” sounding intense Filter FM at about the frequency of the Oscillator, but at other times at half the rate (an octave below), or less. This is somewhat like not quite blowing a trombone into its second octave. Thus, a totally repetitive sequence can result in randomly very different sounds. I have had settings where the state of this self-oscillation for a particular note in the bar varies from bar to bar, but remains stuck in one state or the other for the duration of each note.

Muffler and Audio Filter FM

The muffler works on the output of the VCA, and it is the output of the VCA which drives the Filter FM pot. Since the Muffler decreases the level – and particularly the extremes of level – it will reduce the effect of Filter FM and change its nature. Likewise, the Filter FM pot will have less effect if the VCA output level is low due to the Overdrive pot being set low.

Battery arrangements for memory data retention

Please see the separate manual concerning this: DF-Memory-Backup.pdf.

Operation from C-cell batteries

Please be wary of inadequate supply voltage from batteries or the external power adaptor if you experience faulty behaviour with the Devil Fish’s sequencer. There can be all sorts of trouble, such as the sequencer stopping (and not responding to front panel buttons) or playing patterns incorrectly or not at all. There have been many instances of Devil Fish users being perplexed at a malfunction, only to find the problems are resolved with a fresh set of batteries.

Please use Alkaline C-cell batteries, rather than ordinary dry-cells. NiCad or Nickel Metal Hydride rechargeable batteries are 1.2 volts per cell, and will not provide sufficient voltage to run a TB-303 or Devil Fish reliably.

The TB-303 is fussy about the voltage of its C-cell batteries. Likewise, if it gets too little voltage from an external power supply, then the internally regulated version of that supply voltage will drop below 6.0 volts, and trouble may occur. The Devil Fish draws more current and therefore is still fussier about these low voltages, however in August 2005 I began making additional changes to the Devil Fish (Version 3.0C and 4.0C as described below in the Version History) which improve the way the CPU voltage is generated and so make these machines somewhat less sensitive to low battery (or adaptor) voltages than a standard TB-303. This discussion concerns the TB-303’s original CPU. The CPU I use for the MIDI In and MIDI In and Out systems have a separate power supply, and should not be affected by marginal drops in battery or external supply voltage.

Devil Fishes before August 2005 generally could only work from the “top 25% or so” of the energy available from alkaline C-cells. I estimate that a fresh set of C-cells would run

the machine reliably for 3 or 4 hours. Some machines may be more robust and others more flaky – depending on how fussy the CPU chip is. After these changes, I expect machines should run for 5 or 6 hours before the battery voltage falls to the point where the CPU may malfunction. These times are not guaranteed. The actual running times depend on the batteries, the temperature, what the Devil Fish is doing, and especially on the characteristics of the particular CPU chip.

When the on-load voltage of the 4 cells combined dropped below about 5.5 volts (1.375 volts / cell), the TB-303's CPU chip would generally be running from 4.5 volts or less. The CPU chips are only specified to run from 4.5 to 5.5 volts, so if they malfunction below 4.5 volts, it would not be surprising. Each individual CPU has its own lower limit, and this may vary with temperature. The lower limit for proper operation may also rise with age. I have seen particular TB-303s or Devil Fishes become more fussy about supply voltage. This is not common, but it may happen to any machine. Replacement CPU chips are now available, due to them being removed for installation of the Quicksilver 303 system. The failure mode may be the CPU freezing – so there will be no sequencer or front panel activity. Another failure mode may be it stepping through a pattern, displaying things on the front panel etc, but failing to trigger the Gate of the synthesiser – so no sound is played and no Devil Fish LEDs are turned on.

The Version 4.0C changes reduce the voltage drop to the CPU and so enable any given CPU to operate at correspondingly lower battery (or external supply) voltages. I estimate the voltage at the batteries which is required for 4.5 volts to the CPU is reduced from 5.5 volts to about 5.05 volts. This means that the machine will run properly for longer on a particular set of C-cells.

With Version 4.2B (February 2015) and for any earlier machines which we do further work on and send overseas, we install an under-voltage protection system so the machine is not powered at all if the battery or external power supply voltage (after passing though the internal regulator, which attempts to drop it to 6.0 volts) drops below about 5.0 volts. This is to prevent the C-cell batteries from being flattened if the machine is left running from these batteries for a long time. This reduces the chance of the C-cell batteries leaking, and should ensure they retain enough charge to retain the memory data. For a full description of this, please see the separate manual DF-Memory-Backup.pdf.

Please see the discussion below (Known reliability problems) on how the Run/Stop LED is an indicator of power supply voltage. A dim Run/Stop LED indicates that the battery or external power supply voltage is too low.

Power Adaptors

The Devil Fish with MIDI In or MIDI In and Out and the headphone amp operating, draws 180 mA from the external power adaptor. The lowest current drawn, with few LEDs on and no sequencer, synthesiser, headphone out or MIDI activity is around 150 mA. It is vital that the power adaptor used for the Devil Fish (or any TB-303 or TR-606) be an independent adaptor for this machine alone, and that it be close to 9 volts. 8.5 to 9.5 volts is best.

Until about 2011 I recommended a Boss PSA-240 adaptor for Australia. I similar adaptor could probably be found for various countries depending on the supply voltage: PSA-100, PSA-120, PSA-230 etc. These put out a reliable 9 volts with quite sufficient current for

the Devil Fish. These are the original 1980s design adaptors with a 50/60Hz mains transformer, rectification (such as with four diodes), capacitor and linear regulator. By 2011 these have been replaced by completely different adaptors with similar names: **PSA-100S**, **PSA-120S**, **PSA-220S**, **PSA-230S** and **PSA-240S**. All these “S” model adaptors are “switch mode” adaptors, also with proper voltage regulation.

Switch mode adaptors rectify the mains voltage, smooth it with a capacitor, and then switch it on and off at a rapid rate, such as 50kHz, into a small transformer. The output of the transformer is rectified and smoothed with a capacitor. An opto-coupler feedback mechanism controls the switching duty cycle to keep the output voltage close to 9 volts. Switching power supplies are lighter, more complex, more efficient and (now, not in the 1980s) less expensive to make. The are also a source of electrical noise, since no matter how well the output is smoothed, the capacitive coupling in the 50kHz transformer, combined with switching a very high voltage at this frequency (~320 volts for the 240V model) will couple some 50kHz signal to the device which is being powered. While this 50kHz is inaudible, it might interact with other devices, such as various digital audio sampling systems to create unwanted audio signals of some kind. In attempt to reduce this, the “S” models pass the output cable through two toroidal inductors, in a separate small box, in the middle of the cable.

A further source of interference from these modern adaptors may be that they typically have substantial capacitors between both the active and neutral mains terminals and the negative DC output wire. These capacitors may be an attempt to satisfy electromagnetic interference emission regulations, but they also have the effect of capacitively coupling the output of the adaptor to mid-way between the active and neutral line. This coupling may induce hum or high frequency noise from mains switching transients (such as a fridge turning on or off) into the audio system.

These “S” model adaptors are fine for the Devil Fish, or any other TB-303, since they are well regulated. However, it is possible that any switching supply might, in some complex audio setups, cause unwanted sounds. Its not just the device the switching supply is driving – the capacitively coupled signal may permeate the entire system, and there are likely to be multiple switching supplies doing the same thing.

In short, the PSA-xx0S models should be fine, but in the unlikely event that there is unwanted interference in the entire audio system, it might be a good idea to run try to isolate the cause by running the Devil Fish from batteries.

Beware of other adaptors. Just because an adaptor is labelled as “9 volts 300mA” does not mean it actually puts out 9 volts when powering the Devil Fish. It may be designed to put out at least 9 volts under worst-case conditions (usually when warm, which increases the resistance of the copper windings of the transformer) with a load of 300mA and a slightly lower than normal mains voltage. But this means that with a good mains voltage and a lighter load, it will probably put out 10 or 11 volts. If you are going to use unregulated adaptors (most plain, non-switching, adaptors are unregulated) then it is best to choose a 9 volt one with a lower rated current than a higher. For instance, the voltage supplied under a 150 mA load by a “300 mA” adaptor might be an acceptable 9.7 volts, while with a “1000 mA” adaptor the voltage might be a damaging 11 volts.

In 2012, the great majority of power adaptors are switching adaptors – and these should all be well-regulated. However, they may cause noise in the whole audio system.

A good adaptor will put out 9.0 to 9.5 or maybe 10 volts maximum when the Devil Fish is running from it. If the Run/Stop LED does not light fully and without fluctuation when the sequencer is running, then the external power adaptor (or the C-cell batteries if this is what you are using) are not supplying sufficient voltage.

The machine may work OK with higher input voltages, for a while – but the internal regulator transistor will be asked to drop 180 mA through more than its intended 3.0 volts (9 volts external dropped to 6 volts internally means a 3.0 volt drop across this power transistor and therefore a 0.54 watt dissipation). If you notice the back right of the machine getting too hot, then you are probably driving it with an adaptor which is putting out too high a voltage. This probably won't damage the transistor immediately, but extended use will damage it and make the machine unusable except from C-cell batteries. See further discussion below in the "Q45 overheating" section of "Known Reliability Problems".

Do not use share one power adaptor amongst multiple machines. Theoretically it may work if the two machines are identical, such as two TB-303s etc. However, this sharing of 9 volt adaptors with other machines is likely to damage machines such as the TR-606 or TB-303 / Devil Fish. These use a regulator in the negative lead, so this lead drops to -3 volts for a 9 volt input, causing the positive lead to be the +6 volts the internal power supply requires. Most other musical instrument devices ground the negative lead – and the TB-303 / Devil Fish will have its ground connected via audio leads to the ground of the other device. This would bypass the TB-303's internal regulator, and force the positive lead to +9 volts, or whatever higher voltage the adaptor is putting out. This is likely to damage the internal power supply and it would not be surprising if it destroyed the CPU chip, which would then be running from 8.0 or more volts, while its absolute maximum voltage is 6.0 and while it is only specified to operate properly on 4.5 to 5.5 volts.

Optional Headphone Output

In October 2012 I can introduced an option for a 3.5mm Headphone Socket between and above the Power and Audio Out sockets. This is a stereo 3.5mm socket with the original Headphone Amplifier driving both the ring (right) and tip (left) connections via their own 10 ohm resistors.

This is identical to the circuit of the original Headphone socket of the TB-303, except that with that system, the Headphone Amplifier was only turned on when a 6.5mm plug was inserted into the socket. With the new arrangement, the Headphone Amplifier is turned on at all times, which adds about 17mA to the power consumption. This is around 10% of the normal current consumption.

Without this mod, I use the old Headphone Amplifier to drive the Audio Out from Filter. The Headphone Amplifier has a 5 to 6 volt peak-to-peak output range. With this mod I install a new amplifier for the Audio Out from Filter, with an approximately 10 volt peak-to-peak output. So with this mod, there is a somewhat higher output level before clipping on the Audio Out from Filter circuit.

With the new Headphone Socket, very high output levels – high signal levels in the Devil Fish circuitry together with the Volume pot being set high – will lead to some distortion in the Headphone output. This is the same as what would happen in an unmodified TB-303, except that the unmodified TB-303 could not produce such high level signals.

The dual 10 ohm output circuit with the original, large, 1000uf bypass capacitor is capable of driving headphones hard, including headphones with impedances as low as 8 to 16 ohms. If you want to drive a small loudspeaker, please use a stereo socket and tie both the ring and the tip of your plug together, with that driving one terminal of the speaker, with the other terminal going to the ground of the plug.

In general, do not plug a mono 3.5mm plug into this socket, because that will short the ring connection to ground, causing the Headphone Amplifier to work hard driving its signal into a 10 ohm load, for no good purpose. If you want to use a 3.5mm mono socket to get a second audio out from the machine, please plug it in half-way, so the tip of the plug touches the ring connection of the socket.

Optional Switch for Audio In to Filter

I can install an extra three position toggleswitch, usually located between the Tempo and Track/Pattern Group Selector knobs, to enable or disable the Audio In to Filter signal, which is put into the machine via the old Mix In socket on the left of the rear panel.

It has three positions:

Position	**Audio In to Filter enabled**	**Physical switch action**.
Up	Yes	Stays in this position
Middle	No	Stays in this position
Down	Yes	Spring return to middle position

Optional Quicksilver 303

I can install the Quicksilver 303 CPU replacement system in a Devil Fish. This replaces the TB-303’s CPU and provides new sequencing capabilities, with MIDI In and Out via DIN MIDI connections and via a USB socket. I install a USB isolator for this socket.

If I install this, there can be no 32 Bank Memory system. There is no battery backed up memory, so there is no need for an internal lithium battery or for installing C-cell batteries, unless the batteries are needed to run the machine without a power adaptor. The Quicksilver 303 microcontroller has its own non-volatile memory.

There is a separate manual to describe the particulars of the Devil Fish with the Quicksilver 303. Please see the page: http://www.firstpr.com.au/rwi/dfish/midi-options/ for further details.

Idiosyncrasies

The Devil Fish is a denizen of the catacombs of Idiosyncrasy City. Here are some of its peccadilloes.

With version 2.1 and earlier, there used to be a certain amount of clicking at the start of notes and sometimes at the end of notes – even when no sound was being produced, on un-accented notes when the Soft Attack pot was fully clockwise and the Decay pot was fully anti-clockwise. Version 2.1A largely fixed these clicks, but due to a mistake I made with the choice of a diode, clicks may appear with some machines at high temperatures. In Version 2.1B I further refined the circuit to minimise these clicks under all circumstances.

The TB-303 filter is a diode-capacitor ladder filter – comparable to those in many Moog synthesizers. The filter is unchanged in the Devil Fish, although its audio input can be driven harder and its frequency control can be driven over a wider range by a large number of signals. Electronically its behaviour far from the perfect model of a filter. I still don't know exactly why it sounds the way it does, but it has a fantastic vocal/nasal twang that gives it a really musical spirit. The filter will only self oscillate at mid and high frequencies. Surgical intervention, aimed at improving its gain at lower frequencies, made it sound more like a normal filter, so I abandoned this line of investigation.

With high levels of VCO and/or external signal into the filter, some clipping can occur – depending on the filter frequency and resonance.

With high levels of signal coming out of the VCA and with the Volume pot set at or near maximum, some clipping can occur in the output amplifier. This typically only happens on the loudest (for instance the accented) notes, and can be quite a useful effect.

The polarity of the main output signal is opposite that of the Filter Audio Out signal. If you mix the two into mono, then depending on the VCA gain, the two resulting contributions to the final mix may be equal but opposite signals and so will cancel out.

A useful, convenient and drastic effect is to partially insert a 1/4 inch (6.5mm) mono or stereo plug into the old headphone output socket. This form of Filter FM is described above in the Overdrive, Filter Resonance and Audio Filter FM section above.

Reasons for no audible output

The filter can have such a low frequency that it passes no audio at all. For instance, with notes below the low C (2.0 volts) of the standard range (i.e. in the octave accessible with the transpose down function: 1.0 to 2.0 volts) the Filter Tracking pot will lower the filter frequency.

The Cutoff Pot can be turned anti-clockwise to the point where the filter passes no audio at the frequencies the VCO is producing.

The external Filter CV input can lower the filter frequency, including when 0 volts is applied. Any voltage below about 3.3 volts will lower the filter frequency.

If you hear no sound when the Gate is On (as indicated by the LED in the 'e' of "Devil Fish") and the Overdrive pot is not at zero, then try turning up the Cutoff pot, turning

down the Filter Tracking pot, and removing or changing the Filter CV input voltage. Another reason for not hearing any sound is the Decay pot being fully anti-clockwise whilst the Soft Attack pot is fully clockwise – but only for non-accented notes. Beware too of the waveform switch being in mid-position!

Potential reliability problems

In general I have been very happy with Devil Fish reliability. The seven small pots in the Devil Fish section are made by ALPS in Japan – the same company which makes the original 6 pots along the top, the original Tempo and Volume pots. Despite all the turning these pots have had in 276 Devil Fishes (September 2013), some of which are 20 years old, I have never had a report of one failing. Please don't treat them roughly, but it seems these are remarkably reliable pots.

The TB-303's CPU may freeze or misbehave when operating from C-cell batteries or an external power supply which does not provide sufficient voltage. When the sequencer is running, the Run/Stop LED functions as a power supply voltage indicator. The voltage sensitivity is provided by a separate circuit and is not altered by installing different colour LEDs. The Run/Stop LED should be on brightly, or perhaps just dimming a little when more current is drawn by the Devil Fish LEDs. If it is dim, then the batteries or external supply are not providing enough voltage, and you cannot expect the CPU to function correctly. Failure may involve cessation of sequencing and front panel activity until the machine is turned off and then on again. Failure may also include playing patterns in an erratic manner, problems writing patterns, playing patterns but not driving the Gate (so there is no sound) etc. Please see the section above on operation from C-cell batteries.

CV In socket: internal sequencer CV or MIDI In control misbehaving

An occasional problem is that the internal sequencer does not drive the Devil Fish oscillator and Filter Tracking correctly. (Likewise, the CV Out socket will not respond as it should to the internal sequencer.) With the MIDI In system, the same applies, since the internal sequence and MIDI In system both drive the Digital to Analogue Converter, which goes via switch contacts in the CV In socket to the Slide circuit.

There may be no pitch variation or an incorrect variation. Sometimes the VCO pitch warbles slightly. The cause is the rear-panel external CV In 3.5mm socket. This socket's tip contact also functions as a switch to another contact in the socket so that the internal sequencer's CV (or the CV produced in response to MIDI In) is used when no plug is inserted. This connection between the contacts is metal-to-metal and so should be perfectly reliable. However, it seems that it is possible for the connection to fail or to be flaky.

When this happens, there is no evidence that dust, liquids or misuse were problems. The problem does not necessarily arise due to use of these sockets.

Fortunately, the problem can be fixed simply by inserting a plug into the CV In socket and removing it. This may need to be done a few times before the contact area is freed of whatever contaminants were causing the trouble. If this doesn't work, try twisting the plug clockwise and anti-clockwise as you slowly press it into the socket. This will cause the spring contact to move sideways against the fixed contact.

The sockets I use seem to be robust and have plenty of spring-pressure on the contacts. I don't know of any other "better" sockets and the problem is so rare I cannot reproduce it – so I have no means of being sure I have entirely eradicating it. The problem is occasional, since there have been only a few reports from users and one instance with a newly modified Devil Fish I was testing.

Starting with serial number 084 (13 April 2000) I bent the fixed contact of the CV In sockets a little to increase the pressure the spring contact makes on it. This may improve reliability. I only know of one instance, a 2002 modified machine in 2010, where this problem occurred on a machine with these specially bent socket contacts. Microscopical examination of the faulty contacts is consistent with "fretting corrosion" – localised oxidation caused by slight movement between the contacting surfaces. This CV Input socket had been used frequently, so the surfaces would have touched and moved with respect to each other each time a plug was inserted or removed.

32 Bank Memory system – problems when fresh C-cell batteries are installed

This problem affected the first 32 Bank Memory systems, from July 1999 to March 2000. Please see the separate manual DF-Memory-Backup.pdf for details.

Q45 overheating

This is not a problem for the Devil Fish as such, but a general problem with TB-303s and other devices operating from AC adaptors.

A common problem for TB-303s and I assume Devil Fishes is that the machine is sometimes connected to an AC adaptor or to a DC adaptor which produces significantly more than the required 9 volts. The machine my run properly, but the main regulator transistor in the internal power supply section – Q45 (type 2SB569) – can become overheated. Over time, this may damage the transistor and it may fail completely, or more likely fail to operate properly. You may be able to feel this overheating in the rear right of the machine. Damaged transistors typically show discolouration of the green plastic case and plated copper heatsink. Some are remarkably resilient, operating correctly despite having their plastic and heatsink blackened and even showing blobs of solder leaking from within the transistor itself! I replace the "B569" with a commonly available transistor called a "TIP30", but not all of them have sufficient gain to operate correctly. As is often the case with electronics, many weird and wonderful fault conditions turn out to be caused by inadequate supply voltage, or a faulty power supply.

Generally the Roland or Boss adaptors are fine. Cheaper adaptors may say something like "9 volts 400 mA". This means they are supposedly capable of producing 400 mA of current (milliamps are like pints of water per minute flowing through a pipe) whilst still maintaining a 9 volt (volts are like pounds-per-square-inch of pressure in a water pipe) output. The Devil Fish uses around 85 mA in idle mode and no more than 155 mA when running. The latter figure includes 15 mA drawn by the old headphone amp if a plug is inserted into the socket which is not Filter Out and Filter FM In. Most power adaptors do not have internal regulators. Their output results from a transformer secondary winding going through some silicon diodes and being smoothed by a capacitor. To achieve a minimum voltage of 9 volts (not the average, the minimum after allowing for the 100 or 120 Hz hum variation as the mains charges the capacitor in pulses) at maximum output current (say 400 mA) when the transformer's windings are hot and have a high resistance,

when the mains voltage is rather low (say 110V or 220V AC) then the same power supply, when cool, unloaded and running from a higher mains voltage (120 volts or greater than 240 volts) is bound to put out significantly more than 9 volts. The question is: what voltage is the adaptor putting out in practice, when loaded by the Devil Fish? 10 or perhaps 11 volts is probably OK. Anything above this risks overheating Q45, and so causing damage soon or in the long-term. This is a general problem for TB-303s and all similar machines which run from a power adaptor. I don't know of a specific instance of a Devil Fish being damaged in this way, but I wouldn't be surprised if it occurred.

There is no rule which enables users to choose their external supplies with bullet-proof safety. In general, stick to Boss or other quality Japanese adaptors which are 9 volt DC, and which have a current rating between 150 and 500 mA. If in doubt, have a technician check the voltage of your adaptor when it is operating the Devil Fish. The easiest approach to this is to take the back off the machine and use a volt meter on the circuit board where the power jack is mounted.

Tact switches and pots

Until mid-2010 I replaced the tact switches (the 24 click switches behind the silver buttons) with the original type: ALPS SKHCAA (now known as SKHCBEA010), with a flexible plastic dust-guard, which greatly prolonged their life. Dust (mainly flakes of skin) gets into these original switches and builds up on the contact points, making the switches unreliable. Then the switches "bounce" – meaning they either don't work, or turn on and off several times, when pressed and released once.

From mid-2010, we are installing Omron B3W-4050 sealed tact switches. These should be impervious to dust and liquids indefinitely, so hopefully they will work for many decades without bouncing. The stems of the switches don't quite fit the TB-303 buttons. So I cut two slots in a cross formation into the stems, so it becomes four separately sprung segments, which bend slightly to fit the buttons.

These Omron switches are slightly firmer than the originals and have a good click action. They *may* not hold the buttons in as exact a rotational alignment as the original ALPS switches, so if the buttons are slightly clockwise or anti-clockwise, it would be due to the Omron switches not having such tight rotational registration. These Omron switches feel good and appear to be the best way of ensuring long switch life. An ALPS sealed tact switch (SKQEAAA010) is available, but it has a high activation force, little travel, little difference between the activation and holding forces and therefore a poor click action.

Tact switches which are erratic make the machine difficult or impossible to program. There is no way of repairing them or improving them by spraying *stuff* (oil or anything which comes in a can which claims to fix electrical problems . . .) inside them. In my view, *stuff* should never be sprayed inside anything electronic, unless the component is able to be dismantled and the cleaning done with isopropyl alcohol in a manner that it can be completely cleaned off and then visually inspected. These tact switches cannot be dismantled or improved with any such liquids.

Small pots and toggleswitches in the Devil Fish board

There have never been any problems with the seven beautiful little ALPS pots used in the Devil Fish. Likewise the C&K 8125 switches used beneath the Accent button (and in the memory system) seem to last forever, unless something smashes against the button. There have never been any failures of the 6mm sockets used in the TB-303 (Filter In, Filter Out/FM and Audio Out) – these are remarkably reliable sockets. There have never been any failures of the 3.5 mm sockets of the TB-303 (CV and Gate Out). The only problem with the Devil Fish 3.5 mm jacks is discussed in a section above on the Gate In socket

There is a lifetime “wear out” problem with the three three-position toggle-switches used in the Devil Fish panel. These are of the highest quality, and are made by only one manufacturer: C&K. They are a T211 SHCQE. Their three-position operation depends on the interaction of a small piece of fibreglass-reinforced plastic with the sides of the case, which is made of a similar material. With a lot of use, the sides of the moving plastic piece become rounded from friction against the case. The result is that there is progressively less of a clear distinction between the three positions. There still are three positions, so the switch remains electrically fully functional, but it does not have its original clear positive tactile action. I haven’t tested this to find out how many hundreds or thousands of operations cause a deterioration. I encourage users not to flick these switches back and forth for no good purpose. Repairing the problem is non-trivial.

One approach is not to de-solder the switch, but to leave its base intact on the circuit board, and to unclip the metal part. A new toggle, metal surround and internal contacts and plastic piece can then be clipped to the switch base. Of course this involves complete disassembly and re-assembly of the Devil Fish, which is not for the faint hearted. However, some of the wear occurs in the outer case, so to replace the switch fully, the case and contacts must be removed. I suggest clipping away at the plastic case to remove most of it, so the pins can be pulled out individually. Then use a solder sucker on the holes and install a fresh switch.

Replacements for the 6 small TB-303 pots

Technology Transplant (`www.technologytransplant.com`) sell replacement pots for the 6 small pots along the top of the TB-303. (They also sell replacement Tempo and Volume pots.) There have been several versions of these pots over the years. In March 2006 I received some and when I first used a set in August I found that the Resonance pot is not a linear pot, as it should be. The Resonance pot is a dual 50k pot, with a linear taper, which is ‘B’ in the arcane world of potentiometer nomenclature. So “50KB” is the label of the original and the replacement pots. The Resonance pots I received concentrate most of their resistance variation into the centre of the rotational range. That is to say that very little happens between fully anticlockwise and about 10 o’clock, and likewise very little happens from clockwise back to about 2 o’clock. This could be thought of as being “log” on both ends. They are labelled ‘A’, which normally means log – specifically logarithmic so little change happens when starting from the anti-clockwise position, with the mid-resistance point usually being beyond the mechanical centre point.

This is a minor problem of little concern, since it doesn’t alter the range of sounds which are available. It should be borne in mind when writing down knob settings, and transferring them to another machine with the original type of Resonance pot. Despite

this problem, and the fact that the shafts of these 2006 to 2009 Resonance pots are too large (I drilled out the knob's splined hole) we are very fortunate that Technology Transplant has gone to the trouble of having these pots manufactured.

In late 2009 and early 2010, there was a new batch of pots from Technology Transplant. There is still this minor problem with the Resonance pots being "log" on both ends. However the shafts of all the pots fit the knobs properly, and the pots themselves are a new design which should last for a very long time. The primary failure mode of the original ALPS pots was the outer part of the rotor rubbing on the phenolic board, when the pot was turned and the shaft was pushed down. This would eventually cut through the conductive tracks. The late 2009, early 2010 batch of pots from Technology Transplant have a different internal design, so this cannot occur. With luck, these pots will last a very long time – longer than the original ALPS pots.

The initial set of this 2009 / 2010 batch had shafts which were about 1.6mm too short. I resolve this problem by mounting them with a laser-cut special spacer. I understand Technology Transplant is having a new batch made with a different mounting plate, to achieve the same thing: the body of the pot being about 1.6mm higher than it would otherwise be.

The Resonance pots of this 2009/2010 batch do not have the noise problem mentioned below. Before I install these 6 new pots, I dismantle them and replace the stiff friction grease with thinner silicone grease, so the pots are nice and easy to turn. This grease at the top centre of the pot, where the shaft enters – nowhere near the conductive tracks and wipers.

Replacement Resonance pots become noisy

In 2008 I had some trouble with replacement Resonance pots becoming noisy. The problem is primarily the wipers for the outer section of the pot not making proper contact. Please see the pot-wear/ page at the Devil Fish web site for more information. I have a technique for modifying these pots before I install them which so far has fully eliminated, this problem. This problem doesn't occur with the pots I used from mid-2010 onwards.

Applications

It was quite a few years before the idiosyncratic personality of the TB-303 was fully recognised. Most of the things you do with the Devil Fish will be unique because the combination of your music and the new sounds have never been tried before. There is a great deal to be done, just with the machine as it stands, playing from its internal sequencer, synched up to other equipment. Still, I think, most people see the Devil Fish as a TB-303, typecast in techno or acid music, rather than an instrument, musical character / critter etc. in its own right.

One simple extension is to drive a synthesizer from the CV and Gate outputs and mix the synthesizer's signal into the Devil Fish with the Mix In or the Filter FM. Another is to treat the output of the Devil Fish with EQ, reverb, delay, flange etc. and bring it back into these inputs. One application of the CV, Gate and Accent In and Out signals is to have one Devil Fish slaved to another via these three signals. The two machines can have differing sounds and their outputs can be treated and mixed separately. This sounds great with the two machines running together, but coming out of separate speakers.

Breeding pairs of Devil Fishes are rare, but if you can bring two together, the following "69" configuration is recommended. Have the two machines running as master and slave, via CV and Gate or by Sync with a similar or identical pattern. Alternatively, have them both playing via MIDI In notes. One way or another, have them playing similar or identical notes, with similar or identical settings and tuning. Take the audio out of the left one and feed it into the Filter FM input of the right. Vice-versa from the right audio out to the left Filter FM in. Listen to the two machines in stereo. Turn both Devil Fish volumes down and start them playing. Now slowly turn up the two volumes, and you will hear the increasing sound level and the similarly increasing levels of cross-pollination taking place, since the level of FM for one is dependent on the volume of the other . . . while the sound quality of the other is dependent on its interaction with the output of the first, which is getting louder and the product of the other's increasingly convoluted output . . .

Consider one of my definitions of techno: Machines cranking over – lovingly tended.

Version History

Version 1.0 and 1.1

[April 1993 to April 1994, serial numbers -001 to 016.] There is no musical or functional difference between these versions. Version 1.1 used a more convenient value for the Accent and Normal Decay pots, which simplified the modification a little. In Version 1.0, I had to use different pots while I waited for the right ones to arrive from Japan. Some of these machines had the Sweep Speed switch retrofitted. All version 1.x machines had the Slide Time pot as a trimpot adjustable from the back – which meant it was hardly ever used. (Alternatively, if it was used a lot, it became hard to adjust because the little slot in the trimpot would become worn.) They did not have LEDs or the Filter Audio Output signal. They had a pitch shift problem with longer slide times. They had no Lithium battery. The front panel was laminated cardboard.

Version 2.0

[July to September 1996, serial numbers 017 to 022.] These were the first six printed circuit boards of the new design. The face-plate was of temporary cardboard. Apart from the correction of slide time pitch problems, and the addition of the Sweep Speed switch and the filter audio output, these sound identical to the previous versions, except for a problem with oscillation of the filter frequencies. In late 2009, four of these machines still need to have C14 replaced with a 22uF to correct this problem.

Version 2.1

[September to November 1996, serial numbers 023 to 028.] This is a printed circuit update – removing a few problems in the 2.0 boards which had to corrected manually.

Version 2.1A

[December 1996 to August 1998, serial numbers 029 to 051.] This is the same printed circuit as 2.1, but with some changes to components on the board and to the modifications on the TB-303 main board. These changes almost entirely eliminate clicking when the Decay pot is anti-clockwise and the Soft Attack pot is clockwise.

Version 2.1B

[February 1999.] This is the same printed circuit as 2.1, but with changes to achieve:

1. The reliable elimination of clicks when Decay is fully anti-clockwise and Soft Attack is fully clockwise.

2. The new, more sensitive, Filter CV input arrangement. (Still linear, but with greatly increased sensitivity above 4.2 volts.)

In addition, I used a new label for the back panel of the Devil Fish. A few details of the modifications were changed, such as replacing a resistor rather than adding one in parallel, but these changes do not alter the behaviour of the machine.

Version 2.1C

[30 May 1999] This is the same printed circuit as 2.1, but with further changes to achieve:

1. Filter CV in is now about 1 volt per octave (exponential response). In 2.1A and earlier it was a linear arrangement – a certain number of Hertz per volt. In 2.1B it was linear up to about 4.2 volts and above that, a more sensitive linear response.

2. Internal adjustment to ensure that the maximum resonant filter frequency (no Env Mod, Filter Tracking or external CV In) is 5 kHz – an octave above the standard frequency of the TB-303. Previously component variations caused this frequency to vary somewhat from one Devil Fish to another.

3. The Filter Tracking circuit has been altered to give more tracking at lower settings of the pot. The maximum tracking remains unaltered.

4. A small internal change to stabilise a voltage in the filter driver.

Starting with serial number 070 [19 November 1999] I added a resistor across TM6 to make it easier to adjust the 5.333 volt voltage correctly. This has no effect whatsoever on the sound – it is just to make it easier to calibrate. Sometimes the voltage cannot be calibrated properly with this resistor, so I remove it or replace it with a higher value.

Starting with serial number 081 [4 April 2000] I altered the battery supply arrangements for the 32 bank memory system to avoid potential problems when C-cell batteries are installed. See discussion above on known reliability problems.

Starting with serial number 084 [13 April 2000] I bent the fixed contact of the CV In sockets a little to increase the pressure the spring contact makes on it. See discussion above on known reliability problems.

Version 2.1D – a new Slide In arrangement

[11 November 2003, starting with serial number 157.] All subsequent Devil Fish modified TB-303s have the same sound as with this version of the modifications. The later versions involve some other changes regarding LED brightness, CV inputs and outputs etc. – but these do not affect the sound it makes.

Version 2.1D is the same as 2.1C, but with updates to the Slide In and Gate in circuit as described above and below. This was to make it compatible with version 3.0. which is a new printed circuit design which embodies all these features which previously were modifications to the 2.1 circuit boards. Therefore, version 2.1D is functionally identical to version 3.0.

The musical concept of a slide is for one note event (in terms of triggering envelopes) to begin at one pitch and to transition to another pitch with an audible slew between the two pitches. In the TB-303 sequencer, this is achieved with two or more notes (that is a pitch with a timing value of one or more steps) where the first one or more notes has the Slide bit turned on. The result is that what would otherwise be two note events, with two pitches, and two separate activations of the envelope generators, is turned into a single longer note event, starting at the start of the first note and ending at the end of the second. Thus, Slide in the TB-303 sequencer ties two notes together in time to become one, whilst turning on a “slide slew” circuit (IC11B following C35 driven by the 100K impedance of

the DAC in the standard TB-303) which causes any pitch difference between the notes to be audibly slewed. (Normally, without Slide, C35 is driven by the IC11B op-amp, which follows the DAC voltage directly.)

In MIDI there is no formal concept of a slide. It is possible to use pitch-bend on a single note, but that does not relate to the musical notion of tying two note events into one over time, and it has technical problems including: the need to return at some stage to zero pitch-bend, the lack of reliable control of the amount of pitch bend the slave device implements and the typical inability to arrive at a precise final pitch. Also, smooth slides of pitch are impossible with MIDI pitch-bend, since these are discrete commands.

Since musicians typically conceive of slide as something added to two or more pre-existing note events, rather than slide being a conversion of two or more static note events into one longer note event with a complex pitch variation over time, it is natural that a single control voltage be used to turn on Slide. Prior to version 2.1D, the Devil Fish Slide In turned on the slew circuit, but did not affect the Gate of the synthesiser. This provided maximum flexibility, since there are musically useful reasons for slewing the oscillator's control voltage with respect to the input CV (or the internal sequencer's DAC) without at the same time turning on the Gate. However, in version 2.1D I implemented a system which can still work in this "isolated" way – turning on the slew circuit only – or which could also turn on the Gate.

The most usual concept of Slide is that when such an input is on, the synthesiser's Gate is also on, and that all changes to CV are slewed. This is the "combined" slew and gate mode.

The Slide In voltage of version 2.1D has two thresholds:

1. +2.3 volts and above – turns on the slew circuit. (As for all previous versions.)

2. +4.0 volts and above – turns on the Gate of the synthesiser, if it was not already turned on via the Gate In or the internal sequencer.

Therefore, for ordinary Slide operation, simply have your external MIDI to CV converter (or whatever you are using to control the Devil Fish) provide more than +4.0 volts. 5 volts to any other value, say as high as 30 volts, is fine.

To turn on the slew circuit, without turning on the synthesiser's Gate, use a voltage such as 3.0 volts. If you have only an on/off Gate signal and you want to provide 3.0 volts to the Slide In, then you will need to experiment with external resistors in series, or as a divider, to create this voltage.

Also, with version 2.1D, I changed the Gate In threshold voltage from +1.5 volts to +3.5 volts. This should not have any practical impact, since all MIDI to CV converters can be assumed to put out at least 5 volts for their Gate signal. As before, there is no hard upper limit to the Gate In voltage – up to 30 volts is fine.

Version 3.0

[February, March and August 2004, SNs 162, 163 and 164.] This is sonically identical to version 2.1D. There are two changes:

1. The printed circuit board is a fresh design, integrating the changes listed above which were done as modifications to the 2.1 boards.

2. I pack the six small TB-303 knobs (Tuning to Accent) with a small insert, which together with the “Blu-Tack” which helps stop the knob from coming adrift, causes the knobs to be about 1.5mm higher. This makes them easier to turn.

Version 3.0B

[August 2005, SN 190.] This is sonically identical to version 2.1D. One Devil Fish was made with this version number, but others may be upgraded to it in the future. These are 3.0 boards, but with the 4.0A and 4.0B modifications to cope with all types of TL072 and to make the Normal and Accent Decay LEDs brighter for shorter times.

Version 3.0C

[August 2005, SN 187 and 188.] These use 3.0 boards, but with the 4.0A, 4.0B and 4.0C upgrades as described below. So this is like 3.0B but with longer C-cell battery life.

Version 4.0

[December 2004. SN 165, 166 and 167.] This is functionally identical to Version 3.0 and therefore 2.1D. The printed circuit boards have provision for the MIDI In system.

Version 4.0A

[January 2004. SN 168, 169 and 170.] Apart from a minor matter of LED brightnesses, this is functionally identical to Version 4.0 and therefore 2.1D. A diode has been added to cope with TL072 op-amps which can’t output below their specified limit of 1.5 volts above their negative supply. I was expecting them to go below this when driving the Normal and Accent Decay LEDs and this caused a slight continual glow on one of these LEDs at all times. Serial numbers 168 and after (except perhaps where I use a 3.0 board for customers who don’t need MIDI In) are version 4.0A. The problem only affected the LED – not the sound – and may be present on the three 4.0 machines.

Version 4.0B

[February to July 2005. SN 171 to 186.] Apart from a minor matter of LED brightnesses, this is functionally identical to Version 4.0A and therefore 2.1D. I changed the design slightly so that the Normal and Accent Decay LEDs are brighter when the times for these Decays are very short.

Version 4.0C

[August to December 2005. SN 189, 191, 193, 194 and 195.] This is sonically identical to version 2.1D. Please see the discussion above on operation from C-cell batteries.

Beginning in August 2005, I added three changes which have the effect of increasing the battery life when running from C-cells. These do not reduce the current consumption, but

they reduce the voltage drop between the four C-cell batteries and the CPU, enabling the machine to run from a lower total 4 x C-cell voltage. The standard TB-303 draws about 85 mA, or more depending on the number of LEDs illuminated, whether the headphone amplifier is on, and what signal it is driving into the headphone load. The Devil Fish draws more current, depending on the three new LEDs it may be turning on – Gate and either the Normal or Accent Decay LED. It may draw more current due to the headphone amplifier being on (if a lead is plugged into the old headphone socket) and the MIDI In system draws a little extra current too. The new Blue and other colour LEDs do not draw more current. The new Red LEDs draw the same current as the original LEDs and the other colours, especially the Blue, draw less current because the junction voltage of the LEDs gets higher with shorter-wavelength light. The 32 Bank Memory system does not draw any extra current.

Peak currents for the Devil Fish may be 150mA or so. This reduces the battery voltage more than the usual TB-303 currents, and induces greater than usual voltage drops in some of the internal power supply circuitry. The three 4.0C modifications reduce these voltage drops between the battery (or the external power supply, after the internal 6 volt regulator) and various of the machine. The first two reduce voltage drops to all sections of the machine's power supply – for the CPU and the switching supply which provides +15 volts. The third one only reduces voltage drop to the CPU. The aim of all these is to enable the CPU to operate with battery voltages which are lower than those which would otherwise be necessary.

1. A 1k resistor is wired across R169 (1.5k). This more than doubles the base current to Q44, which – in one machine at least – reduced the voltage drop between Q44's emitter and collector from 112mV to 76mV. (Actual voltages would depend on the particular Q44, on the temperature and on the current being drawn.) This adds about 1mA to the total current drawn, but it saves around 36mV (or more at higher load currents) and so enables the machine to work from lower voltage batteries.

   In V4.B, R169 is removed, and instead of adding a 1k, I use a 560 ohm resistor driven from a resistor-equipped transistor (UNR4212, NPN with two 22k resistors) which itself is driven from a 4.7 volt zener diode from the input voltage. This shuts off Q44 if the input voltage drops below ~5 volts, to stop the C-cell batteries being discharged excessively if the machine is run from them for an excessive time.

2. Short out R168 (2.7 ohms). This is a special resistor, intended as a fuse. It would only operate if there was a drastic problem with the internal circuitry, such as a dead-short failure of Q44, or perhaps a dead-short failure after R168 – but I doubt if a normally driven Q44 could pass enough current to blow this fuse. In the 250 or 300 or so TB-303s and TR-606s I have worked on, I have never seen such a fault and I have never seen one of these "fuses" blow. I have on two or more occasions found machines where this device has a higher than normal resistance – and so needed to be replaced. Shorting out a protection fuse is not generally a good idea, but since this is battery operated equipment, and since the fuse sometimes causes trouble (by developing a higher resistance) and has never been observed to prevent trouble, I think we are better off without it. The benefit is that we no longer have a 368mV (in one machine) voltage drop. This change significantly lowers the voltage the C-cells can go to before the machine will no longer operate.

3. A 1 amp silicon diode 1N4004 is wired across the lower current D2. This reduces the voltage drop to the CPU from about 612mV to 545mV – a drop of 67mV. The silicon junction voltage drop is intentional in the design, since (apart from the drops in Q44 and R168 above), D2 is the only mechanism for providing the CPU with its proper voltage. Since four fresh alkaline batteries can provide as much as 6.4 volts no load – hopefully less under load – there needs to be a way of dropping the voltage down to the 4.5 to 5.5 volt range. Chips such as the CPU typically have an absolute maximum rating of 6.0 volts, so there should be no danger to the CPU in reducing these voltage drops inside the machine.

Altogether, these changes should enable the Devil Fish to function reliably with lower battery voltages. However, the behaviour of particular CPU chips will vary, so it is not possible to specify exactly what voltages a Devil Fish will work reliably from.

Version 4.1

[November 2005. Starting with SN 192.] This is sonically and functionally (LED brightness etc.) identical to version 4.0C and therefore sonically identical to 2.1D. This is a printed circuit board revision which does not change the functionality.

SN 206 for a customer in the USA was incorrectly labelled as SN 204.

In early 2009, around SN 238, we started using a new batch of polycarbonate faceplates. The original batch were made in Melbourne in 1996 and were shinier – more brightly silvery – than the new batch, which was made in New Zealand. The photo on page 1 shows one of the newer faceplates.

Version 4.2

[December 2009. Starting with SN 246.] This is sonically and functionally identical to version 4.1 and therefore sonically identical to 2.1D. This is a printed circuit board revision which does not change the functionality. The three Red LEDs in the Devil Fish panel are a higher brightness grade, and so may appear slightly brighter.

[August 2010. Starting with SN 248.] We are now installing Omron B3W-4040 sealed tact switches, with their stems modified to suit the TB-303 buttons. Previously, we installed original ALPS SKHCAA switches, with a flexible plastic dust guard which greatly prolonged their life. The Omron switches may last indefinitely, since dust seems to be the only thing which causes tact switches to become unreliable – and the Omron switches are sealed against dust and liquids.

We are also installing a 2009/2010 batch of Technology Transplant replacement pots for the 6 small pots Tuning to Accent. We replace their friction grease with a lighter silicone grease in order to make them very easy to turn. This is easier than the original ALPS pots, and I believe this is best for the fast tweaking which is frequently performed with TB-303s and Devil Fishes. These pots should be more reliable than the original ALPS pots and previous generations of Technology Transplant replacement pots. Those earlier pots could fail due to downwards pressure on the shaft, when the shaft is rotated, leading to the outer part of the rotor cutting through the internal conductive tracks. This can’t happen with the 2009/2010 batch, which is a completely new design.

The Resonance pot of this new batch is still a “log” at both ends type, whereas the original ALPS pots were linear. But this doesn’t affect the range of sounds which are

available, just the exact knob position which provides each sound. This batch of pots has shafts which are a little short, so we mount them on an insulating spacer to compensate for this.

White LEDs can be used for the TB-303 front panel. This involves changing the drive circuit for all LEDs, so if White is used, it must be for all the LEDs, except the Run/Stop, which can be White or any other colour.

[January 2012. Starting with SN 260.] Some, many or all TB-303s have a low-level buzz in the background, irrespective of the Volume pot setting. While this is well below ordinary signal levels, it might be annoying. The buzz from LED activity – especially with four LEDs on at once, such as when selecting patterns 1, 2, 3 and 4 – is apparent when running from batteries. A higher frequency buzz, from the Interrupt oscillator, may be audible when running from an external power adaptor. The lower frequency buzz problem seems to be most apparent with the original LEDs or perhaps with any Red LEDs. Blue LEDs have a higher threshold voltage and draw less current. The cause is ground loop problems within the machine. The fix is a wire between the Output socket ground terminal and the ACW (ground) terminal of the Volume pot.

Version 4.2A

[November 2013. Starting with SN 275, but some older machines I work on, such as to upgrade to MIDI In and Out, will be marked V4.2A, even if they use an earlier PCB.] This is sonically and functionally identical (apart from as noted below) to version 4.2 and therefore 2.1D (2003-11-12). 2.1D differs only from the sonically identical Version 2.1C (1999-05-30) due to the Slide In CV input also being able to turn on Gate.

V4.2A Devil Fishes use the 4.2 PCB – or an earlier 3.x or 4.x PCB if they become V4.2A as part of an upgrade. All 4.2A machines have the ground level noise mod mentioned above (January 2012). The other two changes are:

1. The pullup resistor for the Accent CV Out socket is changed from 10k in all previous Devil Fishes to 3.3k. Assuming the machine has a healthy 6 volt supply (it is running from an adaptor which is supplying ~9V, or its C-cell batteries are in good shape) then this should be sufficient to pull up the Slide CV Input socket circuit to activate both its Slide and Gate On functions. This is not guaranteed to work if the machine is running from batteries which have a total voltage less than about 6 volts.

2. I installed a hardware modification to the TB-303 so that the Internal Sequencer's Accent flip-flop is reset at power-on, to ensure it does not power up in the On state. This caused no problems in the unmodified TB-303. It could be a problem with the Devil Fish, due to notes being played by MIDI In and/or CV and Gate In signals: if the Internal Sequencer has yet played any notes since the machine has been turned on, then the Accent output of the Internal Sequencer may be On. The workaround for this problem in Devil Fishes with version numbers 4.2 and below is to briefly run a sequence which has no Accents.

All Devil Fishes I work on after December 2013, which have MIDI In, will have an additional hardware modification (capacitors and resistors to ground from pins 1 and 3 of the Sync / MIDI In socket) to combat capacitive coupling in 5 wire MIDI leads. Starting in September 2014, when I finished the first MIDI In and Out Devil Fish, I used 0.01uF

capacitors in parallel with 33k resistors, to ground, for both the Clock and Run/Stop pins of the Sync socket. The reason for this is explained is the following paragraphs:

> There can be coupling between the two MIDI signal wires (for pins 4 and 5 of the 5 pin DIN socket – the intermediate pins) and the two outside pins (1 and 3) which are for DIN Sync, if the cable has all five pins connected. (A pure MIDI cable, not suitable for Sync, would have pins 4 and 5 as signal wires in a shield which connects the centre pin: pin 2. Such cables will not cause the trouble described here.) The cause is capacitive coupling from the wires for pins 4 and 5 – and perhaps from the ground wire, which may be a shield for the other wires – and the wires which connect to the outside pins 1 and 3, which are for Sync: Run/Stop and Clock respectively. The source signal for this coupling is most likely to be the AC signal of the MIDI Data waveform itself. The capacitively coupled spikes (which this modification prevents) should not have caused any serious problems, but they had been observed – with a long and so high-crosstalk cable – to cause a slight illumination of the Run/Stop LED when it should be Off.
>
> Another potential cause of capacitive coupling trouble in a 5 wire MIDI lead would occur if the master device was not grounded, and was powered from a mains adaptor which was strongly coupled to the mains voltage. (Many switch-mode adaptors have large value capacitors connecting their output to both the active and neutral pins of the mains. This is done to reduce RF emission and so meet the requirements of various regulatory authorities, but it means that if there is no grounding of the device itself, it will typically have a ground voltage of about half the mains voltage. In 230 volt counties such as Australia or the UK, this means over 100 volts 50 Hz AC.) However, this would only occur if the centre pin (2) of the cable did not connect the ground of the master device to the ground of the slave. Normally, with MIDI In sockets, there is no connection to pin 2, and this would leave the master with a high AC voltage on its ground with respect to the slave device. However, the Devil Fish retains the TB-303's 22 ohm resistor which connects pin 2 to local ground. So the just-mentioned 100VAC or similar difference between grounds of master and slave would only occur with the Devil Fish if the middle pin of the cable did not connect on the Devil Fish side, which it does, via the 22 ohm resistor. The same problems could occur if the master device was grounded and the Devil Fish was not, with the Devil Fish being powered by an adaptor which had a high capacitive coupling to the mains. Likewise, if neither device was grounded, but one or both were powered in a way which involved significant capacitive coupling from the mains.

In late 2013 we began using a new set of replacements for the six small pots. These are the same pots as are used in the Cyclone Analogic Bass Bot. The pots we used before this had shafts which were not quite tall enough, so we mounted them no some laser-cut phenolic board spacers. The new pots have a suitable length shaft and don't need any special mounting. We continue to mount the knobs a little higher on the shaft than usual, since this makes them easier to grip.

As before, we dismantle the pots, remove most of the thick friction grease (this is where the shaft and rotor meet the body, it is not in the resistive track and wiper area, though it can migrate there in years to come), and add a little light silicone grease, to make them easier to turn. We also modify them to support the base of the shaft a small fraction of a millimetre higher than how they are normally supported. This is not so much to increase the height at the top of the shaft, but to reduce side-to-side slop in the shaft and to make it more difficult (and perhaps impossible) to cause the rotor of the pot to cut into the conductive and resistive tracks if the knob is pressed down on while being turned.

Version 4.2B

[February 2015. Starting with SN 289.] We changed the arrangements for battery backup supply for the memory. This includes an undervoltage protection system so the power supply is only enabled if the battery voltage (or the adaptor voltage, after passing through the internal ~ volt regulator) drops below about 5 volts. Please see the separate manual DF-Memory-Backup.pdf

Document history

- 1996-09-13: Initial version of "Release notes"
- 1996-10-04: Updated to reflect the availability of patch sheets and polycarbonate face-plates.
- 1999-06-01: For V2.1C.; 1999-02-05: For V2.1B.; 1997-09-22: For V2.1A.
- 2000-03-09: Added a section on "Known Reliability Problems".
- 2000-04-12: Added to the "Known reliability problems":
  - Discussion of the CV input socket problem.
  - An update on the 32 bank memory system C-cell battery problem.
- 2003-11-11: Added section on Slide In for V2.1D. Split the Slide section into Slew and Threshold sections. Added schematic of diodes for pre-V2.1C Slide In activation of Gate. Mentioned replacement pots in normal and long-shaft lengths. Minor improvements to the text, such as a description of "random" patterns of data in memory chips which are "cleared".
- 2004-02-12: Added the V3.0 notes.
- 2004-12-09: Added notes on V4.0 and corrected erroneous resting voltage for Filter Frequency, which is 3.3 volts but was previously stated to be 2.3 volts.
- 2005-01-18: Added notes about V4.0A.
- 2005-02-10: Added notes about V4.0B. Added a section on power adaptors.
- 2005-08-15: Added notes about V3.0B.
- 2005-08-26: Added notes about V4.0C and 3.0C. Added C-cell battery section and extra information on battery voltages and Run/Stop LED as a power supply voltage indicator.
- 2005-11-22: Added notes about V4.1.
- 2006-08-25: Added note about restricted active rotational range of replacement Resonance pots.
- 2007-08-31: Revised Boss adaptor details to mention PSA-120. Fixed a formatting problem.
- 2009-12-15: Added notes about V4.2.
- 2010-01-03: Replaced HTML page of "Release Notes" with this PDF User Manual.
- 2010-03-23: Corrected (page 16) "prior to version 2.1C can't internally use the Slide In voltage" to refer to 2.1D.
- 2010-04-25: Added note in Introduction about occasional problem with the CV In socket. Revised the section about this problem in the Known Reliability Problems section.
- 2010-08-16: Updates for:
  - Omron sealed tact switches instead of ALPS unsealed tact switches with a flexible internal dust guard.
  - The 2009/2010 batch of Technology Transplant 6 small pots, which should be more reliable than the previous batches and the original ALPS pots.
  - We can now install White LEDs on the TB-303 front panel.
- 2010-09-19 & 2010-08-25: The stems of the Omron tact switches now modified with two cuts through the middle, rather than by making the outside of the stems slightly smaller.
- 2012-01-14: Added note in Version 4.2 section about wire between Output socket and Volume pot to reduce background noise. Updated the Power Adaptor section to cover the PSA-xx0S switching adaptors.
- 2012-10-05: Added sections for the optional Headphone socket, Audio In to Filter switch and Quicksilver 303 CPU replacement system.
- 2013-09-19: Added mention of the MIDI In and Out system and a note about capacitive coupling to the mains in switch mode power adaptors.
- 2013-11-02: Added section on V4.2A.
- 2014-09-16: Added to the V 4.2A section further information on: capacitors and resistors on the Sync socket for MIDI In or MIDI In and Out; and on replacements for the six small pots.
- 2015-02-06: Added the Version 2.4B section. Updated the description of battery arrangements for memory backup and pointed to a new manual DF-Memory-Backup.pdf which describes these fully.